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Deterministic Quantum Emission in an Epitaxial Two-Dimensional Material

Michael Pettes, Los Alamos National Laboratory

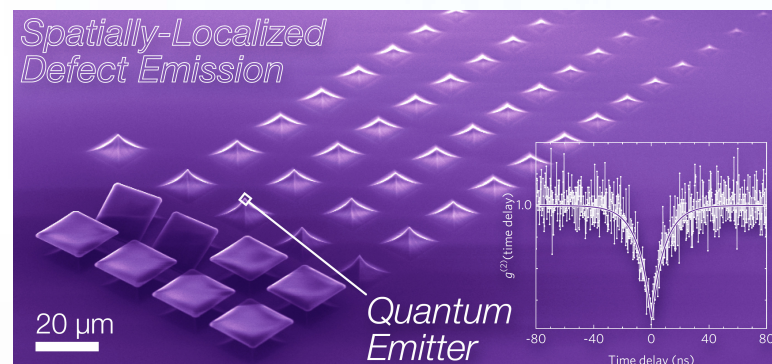
Intellectual Merit: LANL CINT scientists and their collaborators at UConn, AFRL, Penn State, and U. Oregon have discovered a method to create spatially localized quantum emission sites in a wafer-scale transition metal dichalcogenide film, WSe_2 . The team's objective was to determine the role of strain in creating localized quantum emission sites in order to learn how to control their properties through strain.

Because the WSe_2 was very thin, it conformed to the radius of ultra-sharp tips with sub-10 nanometer diameters, and bent towards the substrate. The resulting strain was enough to change the electronic structure, but only at the tips. The affected area emitted light that was fundamentally different in nature than that from the rest of the WSe_2 film, where photons were ejected one-by-one, achieving what is referred to as deterministic quantum emission.

The team published the results as a Featured Article in the May 27th issue of *Applied Physics Letters*.

Link to LANL press release:

<https://www.lanl.gov/discover/news-release-archive/2019/May/0529-quantum-information.php>



Scanning electron micrograph of the array used to create deterministic single photon sources in epitaxial tungsten diselenide. Inset shows the Hanbury-Brown Twiss interferometry measurement proving quantum emission.

W. Wu, C. K. Dass, J. R. Hendrickson, R. D. Montañó, R. E. Fischer, X. Zhang, T. H. Choudhury, J. M. Redwing, Y. Wang, and M. T. Pettes*, "Locally defined quantum emission from epitaxial few-layer tungsten diselenide," *Appl. Phys. Lett.* **2019**, 114(21), 213102. <https://doi.org/10.1063/1.5091779>

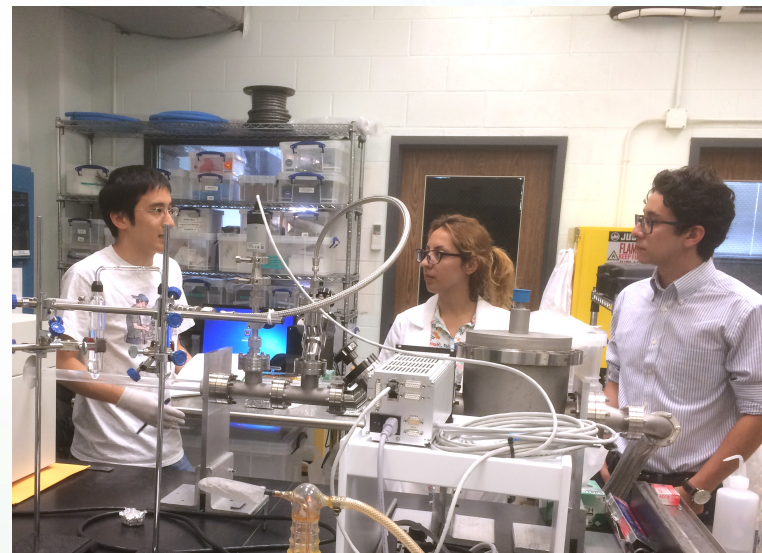
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Broader Impacts: This study contributes to the push for beyond lab-scale quantum materials needed for all-optical quantum information science. These technologies will rely on entanglement between single photons, and for that to happen single photon sources are needed. This study discovered one new way to produce these quantum light sources which uses distorted two-dimensional materials as the light source.

Broadening Participation: Raul Montaña, an undergraduate engineering student participating in Dr. Pettes's lab through the NSF REU program (#1560098, Prog. Mgr. Mary Poats), was able to contribute to this project including by working at the Air Force Research Laboratory in WPAFB, earning co-authorship on the paper. This exposure to "frontline research made me want to pursue real research as a graduate student," says Raul. It also helped lead Raul to a National GEM Fellowship and admission to the University of Texas at Austin Ph.D. program where he is working on a related topic.



The study's first author Wei Wu (left) and Raul Montaña (right) work with Dr. Raana Kashfi-Sadabad (center) in the Pettes laboratory. The hands on work contributed directly to NSF broadening participation goals and Raul is now a GEM Fellow at UT Austin.